WE CLAIM:

1. A component comprising:
a silicon-based substrate; and
a protective coating for the substrate, the protective coating including tantalum oxide (Ta_2O_5) and an additive for suppressing transformation from beta Ta_2O_5 to alpha Ta_2O_5.

2. The component according to Claim 1, wherein coating includes a mixture of tantalum oxide (Ta_2O_5) and an additive chosen from the group consisting of Al, Hf, Si, Ln (rare earth including whole lanthanum series and yttrium) Mg, Mo, Ni, Nb, Sr, Ti, and Zr.

3. The component according to Claim 2, wherein the coating further includes an additive selected from the group consisting of nitrides, carbides, borides and silicides.

4. The component according to Claim 1, wherein the substrate is one of a silicon nitride substrate and a silicon carbide substrate.

5. The component according to Claim 1, wherein the additive includes aluminum oxide (Al_2O_3).

6. The component according to Claim 5, wherein the aluminum oxide is in the range of about 1-50 mol% during application of the coating.

7. The component according to Claim 5, wherein the aluminum oxide is based on starting material in the range of about 1-50 mol%.

8. The component according to Claim 1, wherein the additive includes La_2O_3.

9. The component according to Claim 8, wherein the La_2O_3 is in the range of about 1 -10 mol% during application of the coating.

10. The component according to Claim 8, wherein the La_2O_3 is based on starting material in the range of about 1 -10 mol%.

11. A component, comprising:

a substrate formed of silicon nitride or silicon carbide; and

a thermal protective coating of crystalline composition on an outer surface of the substrate; and

the thermal protective coating including a mixture of tantalum oxide (Ta_2O_5) and an additive of at least one of Al_2O_3 and La_2O_3.

12. The component according to Claim 11, wherein the Al_2O_3 is in the range of about 1-50 mol%.

13. The component according to Claim 11, wherein the La_2O_3 is in the range of about 1-10 mol%.

14. The component according to Claim 11, wherein a surface of the coating has needle-shaped $La_2O_3 - Ta_2O_5$ precipitates.

15. A method of protecting a silicon nitride (Si_3N_4) or silicon carbide (SiC) substrate against repeated thermal cycles at elevated temperatures, the method comprising:

mixing an additive including an oxide, compound or its precursor chosen from the group consisting of Al, Hf, Si, Ln (rare earth including whole lanthanum series and yttrium) Mg, Mo, Ni, Nb, Sr, Ti, and Zr to a quantity of tantalum oxide (Ta_2O_5) powder;

preheating the mixture; and

applying the heated mixture to the substrate.

16. The method according to Claim 15, further comprising firing the substrate and applied mixture to form a solidified protective coating on the substrate having a thickness between 0.5 to 10 mil.

17. The method according to Claim 15, wherein aluminum oxide (Al_2O_3) in the range of about 1-50 mol% is mixed with the Ta_2O_5 powder.

18. The method according to Claim 15, wherein La_2O_3. in the range of about 1-10 mol% is mixed with the Ta_2O_5.

19. The method according to Claim 15, wherein the mixture is preheated to a temperature of about 1000°C before applying the mixture to the substrate

20. The method according to Claim 15, further comprising heating the mixture to a temperature of about 1600°C and then grinding the mixture before applying the mixture to the substrate.